Electronic
C-1 AUTOPILOT
VERTICAL FLIGHT GYRO

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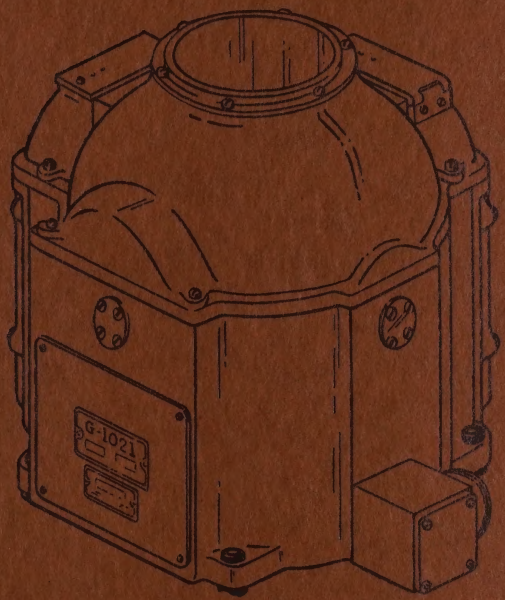
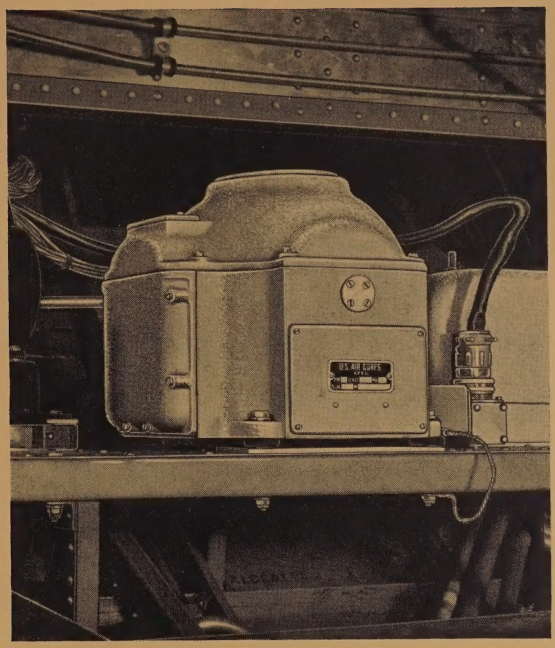


Transvision

TECHNICAL PRESENTATION BY JORDANOFF

MINNEAPOLIS-HONEYWELL REGULATOR COMPANY
AERONAUTICAL DIVISION
MINNEAPOLIS, MINNESOTA



Vertical Flight Gyro

INSTALLED IN A FLYING FORTRESS

Whirling at 7500 r.p.m., the spinning rotor in the Vertical Flight Gyro becomes "fixed in space" and stands erect... unaffected by the rolling and pitching of the airplane.

Sensing every minute deviation, it flashes 105 directive messages each second to the other electro-mechanical units of the Autopilot, telling them . . . "Raise right wing 2°" . . . "Nose dropping, apply up-elevator" . . . and then, "Hold tight — you're on the beam!"

Continuously on duty, it directs the Autopilot system in its manipulation of ailerons and elevators for accurately maintaining level flight.

VERTICAL FLIGHT GYRO

The Vertical Flight Gyro is the Autopilot's reference for maintaining the airplane in straight-and-level flight; it detects deviations of the airplane around both its roll (aileron) and its pitch (elevator) axis. Precision construction of this intricate mechanism, assures unusually accurate operation.

The operating assembly is housed in a sturdy Outer Case (1) of cast duralumin. The inspection plate, to which the name plate is riveted, permits access to the interior. The operation of the gyro can be observed through the transparent window in the top of the cast duralumin Cover (2), and the potentiometers may be inspected by opening the two access doors in the Cover. The Cardan Gudgeon Pin (3) extends into the interior to provide a support in the pitch axis for the Cardan Ring and the Bottom Bail. The Top Bail Gudgeon Pin (4) provides a support for the Top Bail and Counterbalance Guide Channel in the roll axis.

COLOR NOTE

RED: Parts affecting the roll (aileron) axis of the airplane. BLUE: Parts affecting the pitch (elevator) axis of the airplane.

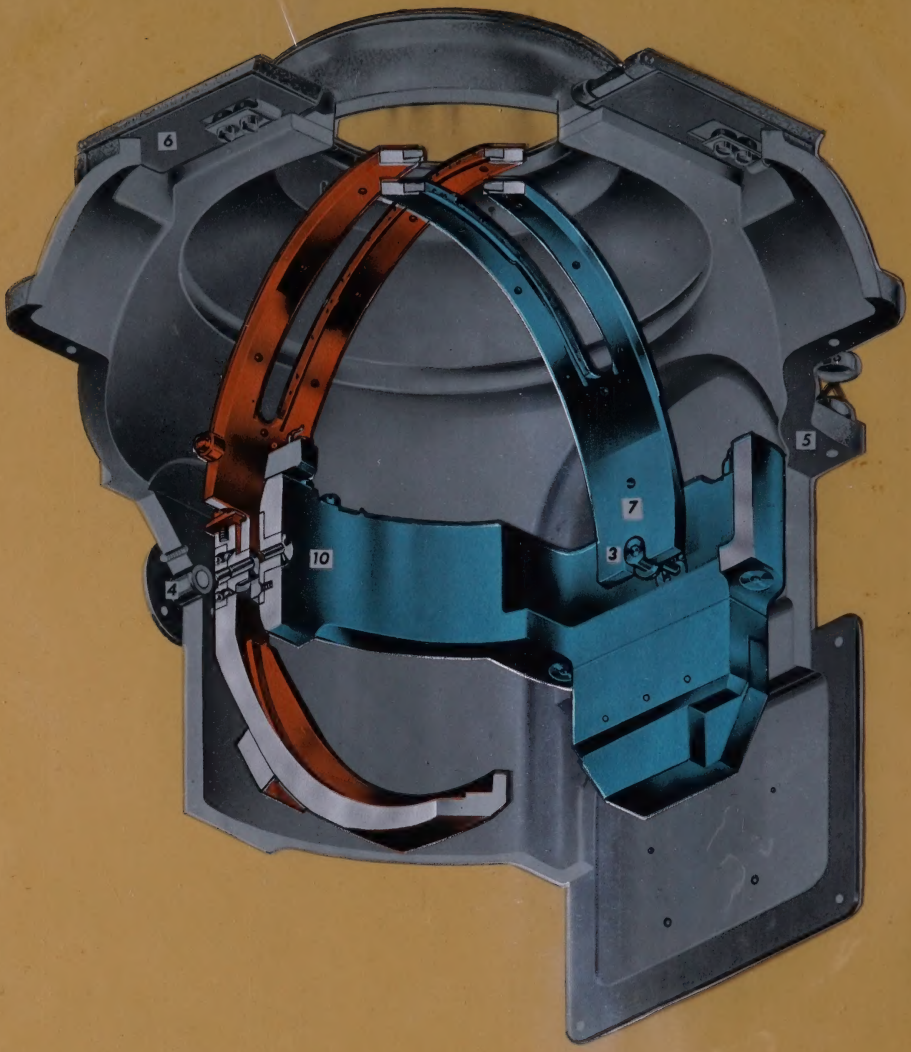
The Cardan Gudgeon Pin (3) protrudes from the section pictured here into the double-row ball bearing race shown on page 3. This bearing, one of the elements in the Gyro's universal joint mounting, allows the Cardan Ring (10) to rotate freely around the pitch axis. Below the ball bearing is the Bottom Bail counterweight, which counterbalances the Bottom Bail (7).

Gaskets (5) and (6) seal the case against dust and moisture. Similar gaskets are used on the inspection plate and on the Bottom Access Cover (page 10).

The Bottom Bail (7) and the Top Bail (8) ride loosely on their Gudgeon Pin sleeve bearings. These bails erect and maintain the gyro in a vertical position with respect to the earth, regardless of the movements of the airplane. The inner surfaces of the bail slots are lined with cork. Two rollers, one for each bail slot, rotate about a stationary shaft fastened to the Rotor Case and in line with the gyro spindle. The Bottom Roller is driven by gears; the Top Roller is spline-connected to the Bottom Roller. When the gyro spindle is

not vertical, the force of gravity pulling down on the bails pushes their cork surfaces against the rotating rollers. The friction thus produced causes precession; that is, the gyro spindle moves at right angles to the frictional force applied. This precession force against the bails gradually pushes them back up into their erected vertical position. When vertical, the bails vibrate back and forth across the rollers to produce equal friction and thus equal erecting forces on opposite sides of the slots. This action holds the gyro spindle vertical.

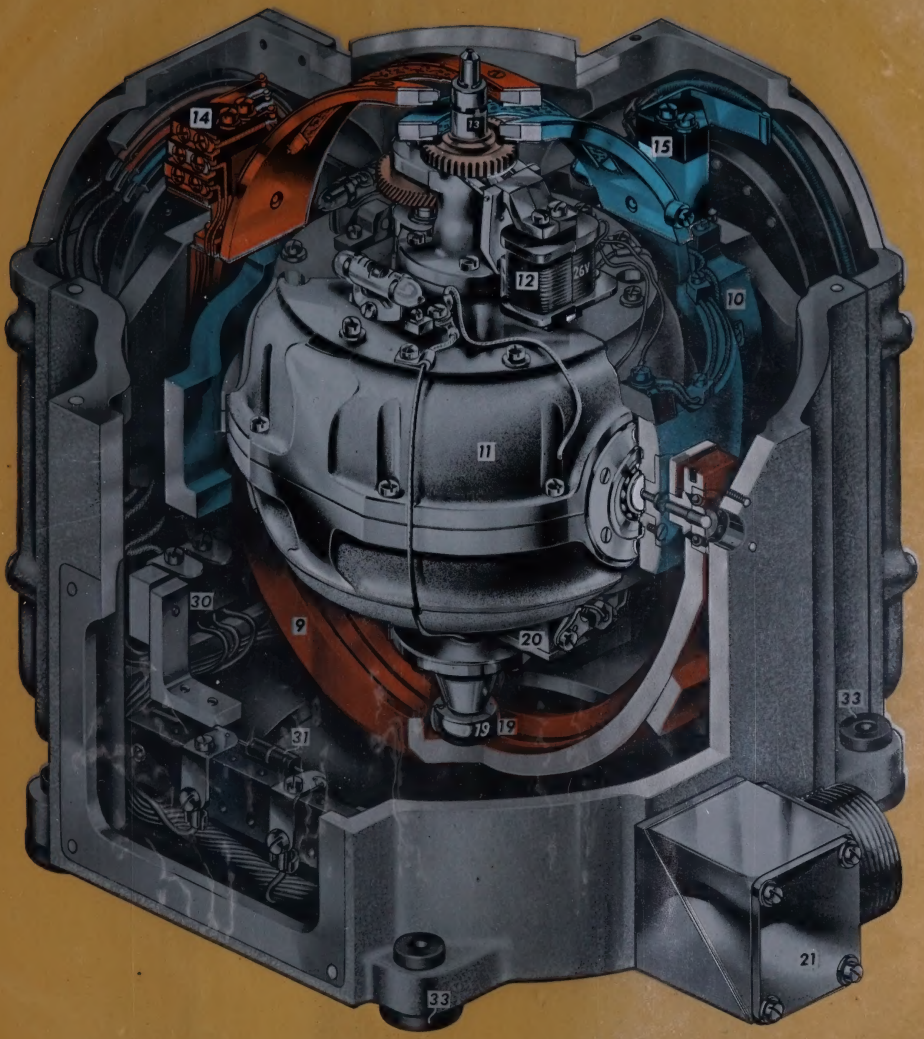
The Counterbalance Guide Channel (9) rotates around the airplane's roll axis on double-row ball bearings. It imparts the stability of the Rotor Case (11), page 5, and its attached lower Guide Roller (19), page 7, to the Triple Pot Wiper Block (14,) page 5. It also counterbalances the weight of the Top Bail assembly to eliminate precession of the gyro while the airplane is in a turn.



The Cardan Ring (10) is a part of the universal joint mounting which supports the Rotor Case (11) in the Outer Case. The Outer Case may tilt 47 degrees in any direction with respect to the Rotor Case, which maintains its stable vertical position.

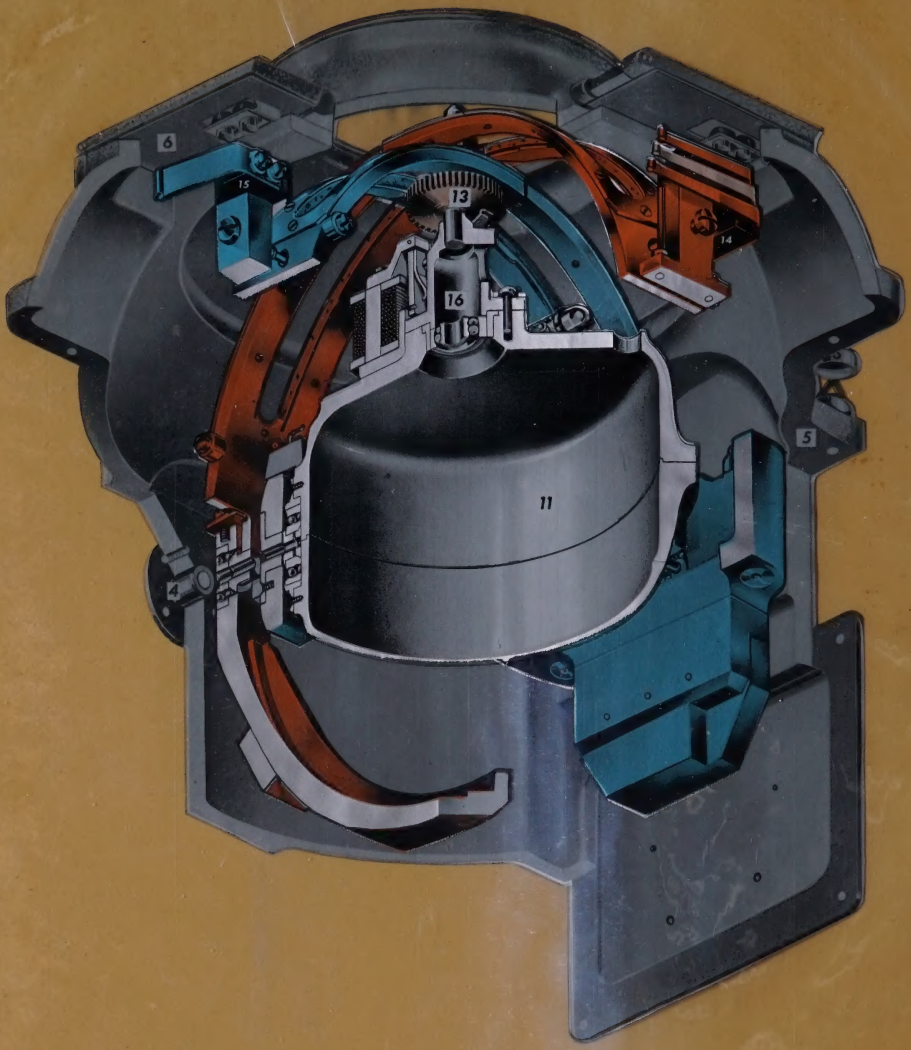
The Rotor Case consists of two halves, upper and lower, held together with machine screws. Mounted on the top of the upper half are two bubble-type leveling vials and the Erecting Cutout Mechanism.

Switches in the Turn Control and in the Directional Panel (on the Directional Stabilizer) automatically energize the Erecting Cutout Electromagnet (12) whenever a turn is being made. The hinged armature clapper with its two forked fingers is then attracted to the magnet; this movement causes the Bottom Roller and Gear (13) to drop down and disengage the Bottom Roller from the Top Roller, stopping the rotation



of the Top Roller. When the airplane resumes level flight, a switch opens the Electromagnet circuit, and the Armature Return Spring (page 8) again raises the Bottom Roller and Gear to its engaged position with the Top Roller. The bail-erecting system then resumes its erecting action.

The Erecting Cutout mechanism is provided to prevent false erection of the gyro during a turn. It is apparent that, when the airplane is in a turn, the Top Bail is thrown by centrifugal force against the Top Roller. This force is counterbalanced by an equal force applied to the Guide Roller (19), page 7, by the Counterbalance Guide Channel; but if the Top Roller were spinning it would rub against the bail and produce a frictional force which would cause the gyro to precess toward the center of the turn.

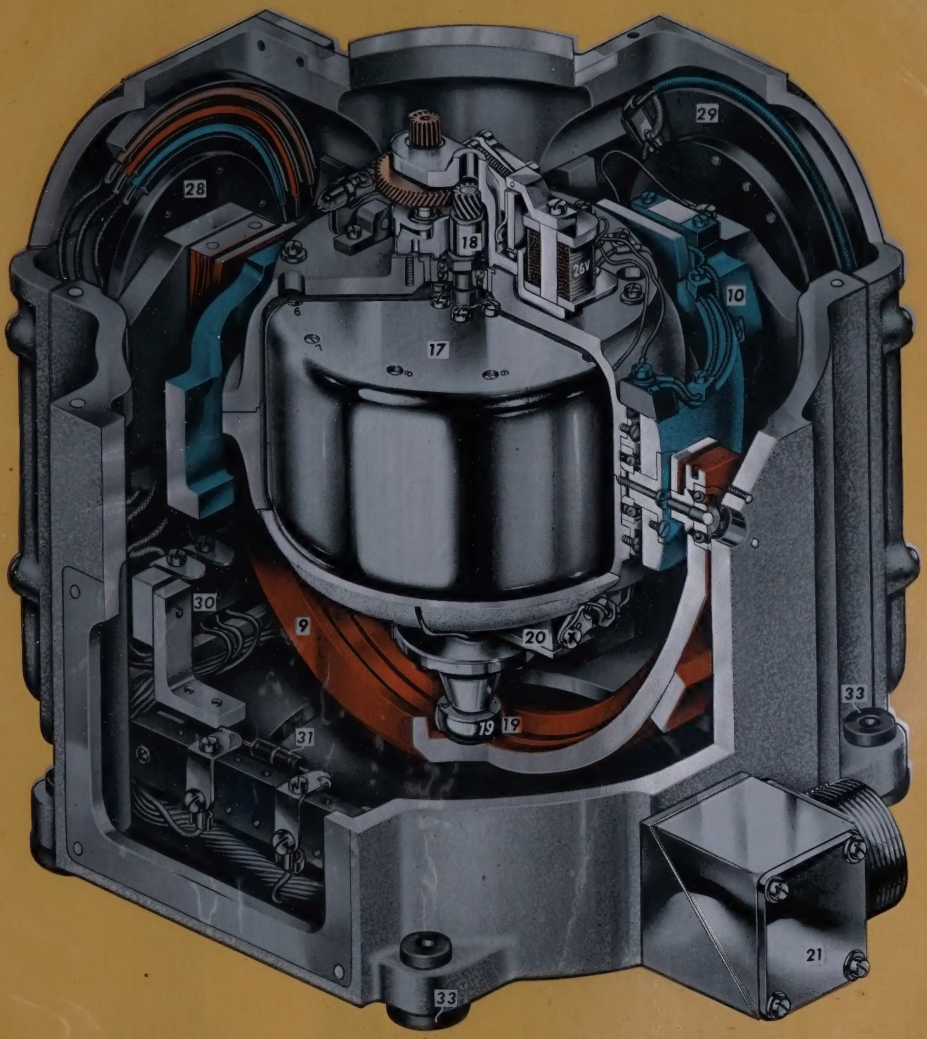


The Triple Pot Wiper Block (14) is mounted on a pedestal attached to one end of the Counterbalance Guide Channel (page 3). The three pot wipers attached to this block are wipers for the Aileron Pickup Pot, top; the Skid Pot, center; and the Up-elevator Pot, bottom. During flight these wipers are held in a vertical position by the Rotor Case (page 5) and the Counterbalance Guide Channel (page 3). Whenever the airplane deviates in flight, the pot windings, which are attached to the Outer Case, move across the wipers to produce electrical signals corresponding to the deviation.

The Elevator Pickup Wiper (15) detects any deviations of the airplane around its pitch (elevator) axis. Its metal pedestal, from which it is carefully insulated, is fastened to the Cardan (page 3).

The Gear Frame (16) is fastened to the top of the Rotor Case and supports the Roller Shaft in line with the Rotor Shaft. It also supports the intermediate gears shown on the opposite page.

The Rotor (17), which spins at the rate of 7500 r.p.m., is both



statically and dynamically balanced. This balance is achieved by the use of twenty recessed balancing screws (see page 8), numbered from one to ten on both the upper and lower Rotor faces. These balancing screws can be adjusted through access holes in the Rotor Case.

The Rotor Shaft Drive Pinion (18) drives the Intermediate Gear and Pinion which in turn drives the Bottom Roller and Gear at a reduced speed, 1/32 the speed of the Rotor.

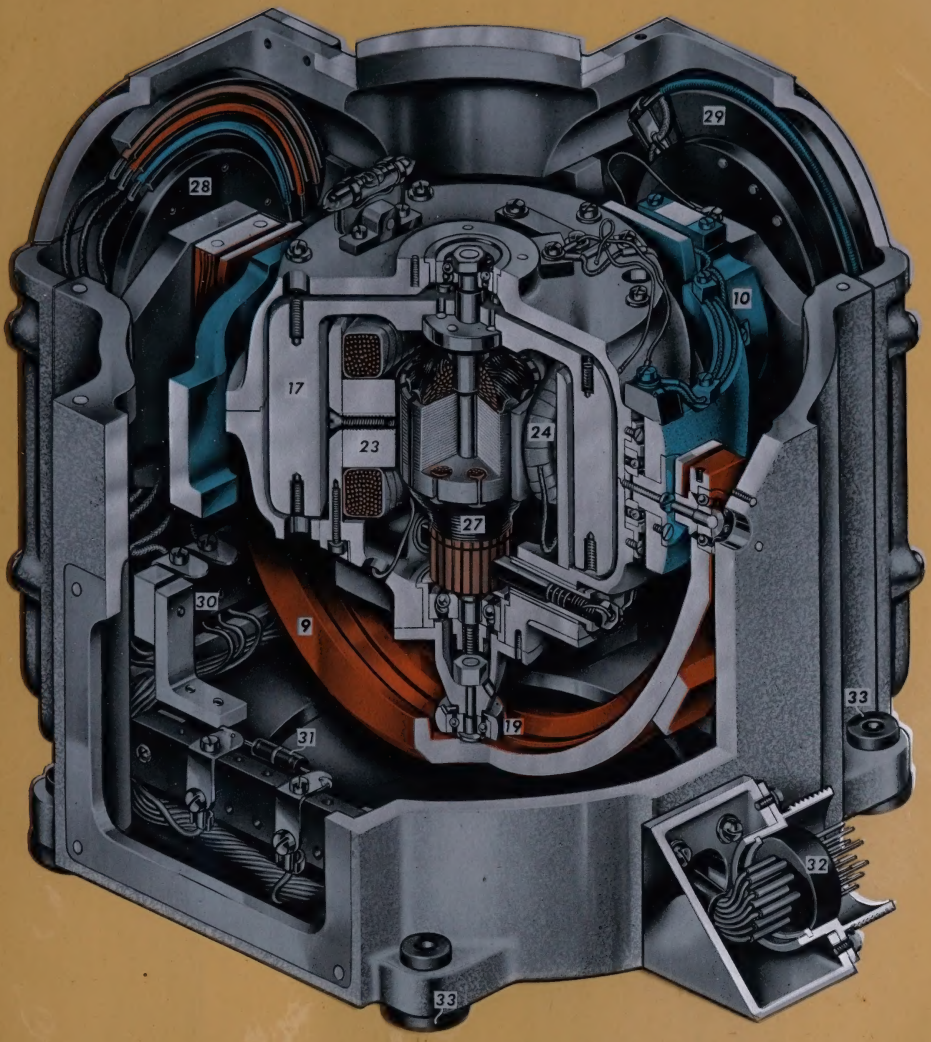
At the bottom of the Rotor Case is the Guide Roller (19), mounted with a hollow conical cap. This Roller swings between the walls of the Counterbalance Guide Channel (page 3) and thus holds the Counterbalance Guide Channel and its attached Triple Pot Wiper Block in the vertical position.

The Commutator Brush Housing (20) is part of the lower half of the Rotor Case. The two brush tubes are insulated from the housing with insulating sleeves. The screw shown at the right of number 20 is the Brush Lead Terminal. Plate (21) is an additional outlet position on the A-N Connector Housing (see page 9), which can be turned so the outlet faces any one of five directions.

The Field Coils (24) are wound on two Pole Pieces (23) which are bolted to the inside of the Field Coil Housing (22). The housing is fastened to the inside of the lower half of the Rotor (17). The laminated construction of the Armature is clearly shown in (25). The main Armature Assembly (27) spins on double-row ball bearings at both top and bottom.

The Guide Roller Support (26) fastened to the bottom half of the Rotor Case supports the Guide Roller, shown here in cross-section.

The Triple Pot Assembly (28) is fastened to the Outer Case. It consists of three semicircular pot windings mounted on a bakelite block. The top winding is the Aileron Pickup Pot; the middle winding is the Skid Pot; and the bottom winding is the Up-elevator Pot. Whenever the airplane deviates



around its roll axis, the deviation is detected by these pots. The electrical signals from the pots result in operation of the ailerons, rudder, and elevator surfaces to produce a perfectly coordinated turn. The Elevator Pickup Pot (29), which detects deviations in the pitch (elevator) axis, is also fastened to the Outer Case.

A bakelite Terminal Block (30) serves as a connector for the pot leads. The Resistor (31) limits the current in the Up-elevator Pot.

All connections to the Vertical Flight Gyro are made through the 14-prong A-N Connector (32). The Outer Case is shock-mounted from the airplane with soft rubber grommets (33).

Rear views of the Triple Pot Assembly (28), the Elevator Pickup Pot (29), and the Terminal Block (30) are shown in the above illustration.

The center-tap contact for the Up-elevator Pot (34) and the center-tap contact for the Skid Pot (35) are shown fastened to the back of the Triple Pot Assembly (28). The Clamping Screw (36) holds the Elevator Pickup Pot in a fixed position with respect to the Outer Case. A similar clamping screw serves the same purpose on the Triple Pot Assembly. Terminal Block (37) provides a convenient place for making connections to the motor, Erecting Cutout, and Elevator Pot wiper.

Gudgeon pin (38) supports the Top Bail and the Counterbalance Guide Channel in the same way as Gudgeon Pin (4), page 1. Gudgeon Pin (39) supports the Cardan Ring in the same way as Gudgeon Pin (3), page 1. The round Inspection Cover (40) provides access to the interior of the Outer Case (1) through the bottom.

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SUMMARY

The Vertical Flight Gyro is one of two gyroscopes employed in the C-1 Autopilot for control of the airplane's flight. Sensitive to deviations from level flight in the roll and pitch axes, it applies signals to the Autopilot Amplifier. The Amplifier, in response, energizes Servo Units, which operate the control surfaces of the airplane to correct roll and pitch deviations.

The other gyroscope, which provides a reference for control of the airplane in the turn axis, is located in the Directional Stabilizer. The Directional Stabilizer and the Servo Units are completely explained in Transvision presentations similar to this.

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